

CLAIMS

What is claimed is:

1. A method of making a magnetoresistive sensor formed with an electrically conductive spacer interposed between a first and a second ferromagnetic layer, comprising the steps of:

selecting a first material having a first electronegativity for said first ferromagnetic layer;

selecting a second material having a second electronegativity for said electrically conductive spacer; and

selecting a third material having a third electronegativity for said second ferromagnetic layer;

wherein an absolute value of a difference between said first and second electronegativities is minimized.

2. The method as in Claim 1, wherein said first and third electronegativities are approximately equal.

3. The method as in Claim 1, wherein said first material substantially comprises a superlattice.

4. The method as in Claim 3, wherein said second material substantially comprises a superlattice.

1 5. The method as in Claim 1, wherein said second material  
2 substantially comprises a superlattice.

3  
4 6. The method as in Claim 1, wherein said first material and  
5 said second material comprise substantially the same crystal  
6 structure.

7  
8 7. The method as in Claim 6, wherein said first material  
9 comprises a first face centered cubic material and said second  
10 material comprises a second face centered cubic material.

11  
12 8. The method as in Claim 7 wherein said absolute value is  
13 less than approximately 0.12 eV.

14  
15 9. The method as in Claim 7, wherein said step of selecting  
16 said second material includes the step of selecting said material  
17 from the group consisting of Cu, Ag, Al, Au, Ir, Pt, Pd, Rh, and  
18 binary, ternary and higher order alloys of said elements.

19  
20 10. The method of Claim 7, wherein said step of selecting said  
21 second material includes the step of selecting said material from  
22 a group consisting of  $\text{Ag}_3\text{Pt}$ ,  $\text{AgPt}_3$ ,  $\text{Cu}_3\text{Pt}$ ,  $\text{CuPt}$ ,  $\text{CuPt}_3$ ,  $\text{Cu}_3\text{Pt}_5$ ,  
23  $\text{Cu}_3\text{Au}$ ,  $\text{Cu}_3\text{Pd}$ ,  $\text{CuPd}$ ,  $\text{CrIr}_3$ ,  $\text{Cr}_2\text{Pt}$  and mixtures of said materials.

11. The method as in Claim 7, wherein said step of selecting said first material includes the step of selecting materials from the group comprising 80Ni:20Fe, Ni<sub>3</sub>Fe, Ni<sub>3</sub>Mn, Fe<sub>4</sub>Mn, FePd, Fe<sub>1-y</sub>Au<sub>y</sub>, where y is an atomic fraction with a value between 0.30 and 0.70, Co<sub>1-z</sub>Au<sub>z</sub>, where z is an atomic fraction with a value between 0.10 and 0.50, 90Co:10Fe, Fe<sub>0.485</sub>Ni<sub>0.418</sub>Mn<sub>0.097</sub>, (48Co:29Ni:23Fe)<sub>(1-y)</sub>Pd<sub>y</sub>, (26Co:44Ni:30Fe)<sub>(1-y)</sub>Pd<sub>y</sub>, where y is an atomic fraction of Pd with a value between 0.12 to 0.30, 33.6Co:20.3Ni:16.1Fe:30Pd, and 18.2Co:30.8Ni:21Fe:30Pd.

12. The method as in Claim 7, wherein said first material comprises a first body centered cubic material and said second material comprises a second body centered cubic material.

13. The method as in Claim 12 wherein said absolute value is less than approximately 0.07 eV.

14. The method as in Claim 12, wherein said step of selecting said second material includes the step of selecting said material from a group consisting of Cr, W, V, Nb, Mo, Ta and binary, ternary and higher order alloys of said elements.

15. The method as in Claim 12, wherein said step of selecting said first material includes the step of selecting ferromagnetic

1 materials from the group comprising  $\text{Fe}_{1-u} \text{Cr}_u$ , where  $u$  is an  
2 atomic fraction with a value between 0.40 and 0.70,  $\text{Fe}_{1-w} \text{V}_w$ ,  
3 where  $w$  is an atomic fraction with a value between 0.25 and 0.35,  
4 ternary alloys of Fe, Cr and V, and  $\text{Fe}_3\text{Al}$ .

5  
6 16. The method as in Claim 1, wherein said steps of selecting  
7 said first material and said second material each includes a step  
8 of defining said first and second electronegativities according  
9 to the following equations:

10  
11  
12  $\chi(\text{FM}) = 0.44 \phi(\text{FM}) - 0.15$ , and

13  $\chi(\text{spacer}) = 0.44 \phi(\text{spacer}) - 0.15$ ,

14 where  $\chi(\text{FM})$  and  $\chi(\text{spacer})$  are said first and second  
15 electronegativities, respectively, and  $\phi(\text{FM})$  and  $\phi(\text{spacer})$  are  
16 work functions of said ferromagnetic layer and said electrically  
17 conductive spacer, respectively.

18  
19 17. The method as in Claim 16, wherein said step of selecting  
20 said second material includes the step of selecting a conductive  
21 alloy having an electronegativity  $\chi_A$  formed of a plurality of  
22 elements 1 through  $i$ ;

1 wherein said elements have electronegativities  $\chi_1$  through  $\chi_i$ ,  
2 and atomic fractions  $f_1$  and  $f_i$ , respectively; and

3 wherein said  $\chi_A$  is defined by the following equation:

4  
5 
$$\chi_A = \chi_1 f_1 + \chi_2 f_2 \dots + \chi_i f_i .$$
  
6

7 18. The method as in Claim 16, wherein said step of selecting  
8 said first material includes the step of selecting a  
9 ferromagnetic alloy having an electronegativity  $\chi_B$  and formed of  
10 a plurality of elements 1 through j;

11 wherein said elements have electronegativities  $\chi_1$  through  $\chi_j$ ,  
12 and atomic fractions  $f_1$  and  $f_j$ , respectively; and

13 wherein said  $\chi_B$  is defined by the following equation:

14  
15 
$$\chi_B = \chi_1 f_1 + \chi_2 f_2 \dots \chi_j f_j$$
  
16  
17

18 19. The method as in Claim 1, wherein said step of selecting  
19 said first material includes the step of selecting a first  
20 Heusler alloy.  
21

1 20. The method as in Claim 19, wherein said first Heusler alloy  
2 has a composition of  $M_1MnM_2$ , where  $M_1$  is an element selected from  
3 the group consisting of Al, Ga, Ge, As, In, Si, Sn and Bi, and  $M_2$   
4 is an element selected from the group consisting of Co, Ni, Cu,  
5 Ir, Pd, Pt and Au.  
6

7 21. The method as in Claim 20, wherein said step of selecting  
8 said second material includes a step of selecting a second  
9 Heusler alloy that is nonferromagnetic and wherein  $M_2$  is an  
10 element selected from the group consisting of Pt, Au, Pd and Ir,  
11 said second Heusler alloy having a bulk resistivity of less than  
12 approximately  $30 \mu\Omega\text{-cm}$ .  
13

14 22. The method as in Claim 20, wherein said step of selecting  
15 said second material includes a step of selecting a material from  
16 the group consisting of Cu,  $Cu_{1-x}Au_x$ , where x is an atomic  
17 fraction between .05 and .15,  $Al_2Au$ ,  $PtAl_2$  and  $Ag_{1-y}Au_y$ , where y is  
18 an atomic fraction less than .25.  
19

20 23. The method as in Claim 1, wherein said first material  
21 comprises a material having a bulk resistivity of less than  
22 approximately  $100 \mu\Omega\text{-cm}$ .  
23

1  
2 24. The method as in Claim <sup>20</sup>~~22~~, wherein said third material  
3 comprises a material having a bulk resistivity of less than  
4 approximately 100  $\mu\Omega$ -cm.

5  
6 25. The method as in Claim 1, wherein said second material  
7 comprises a material having a bulk resistivity of less than  
8 approximately 30  $\mu\Omega$ -cm.

9  
10 26. A method of optimizing the interfacial properties of a  
11 magnetoresistive sensor comprising the steps of:

12 selecting at least one electrically conductive spacer having a  
13 first work function ( $\phi$  spacer); and

14 selecting ferromagnetic layers having at least a second work  
15 function ( $\phi$  FM);

16 wherein an absolute value of a difference between said first  
17 and second work functions is minimized.

18  
19 27. A magnetoresistive sensor comprising:

20 first and second ferromagnetic layers, said first  
21 ferromagnetic layer comprising a first material having a first  
22 electronegativity; and

1 an electrically conducting spacer interposed between said  
2 ferromagnetic layers, and comprising a second material having a  
3 second electronegativity;

4 wherein an absolute value of a difference between said first  
5 and second electronegativities is minimized.

6  
7  
8 28. The sensor as in Claim 27, wherein said second  
9 ferromagnetic comprises a third material having a third  
10 electronegativity and said first and third electronegativities  
11 are approximately equal.

12  
13 29. The sensor as in Claim 27, wherein said first material  
14 substantially comprises a superlattice.

15  
16 30. The sensor as in Claim 29, wherein said second material  
17 substantially comprises a superlattice.

18  
19 31. The sensor as in Claim 27, wherein said second material  
20 substantially comprises a superlattice.

21  
22 32. The sensor as in Claim 27, wherein said first material and  
23 said second material comprise substantially the same crystal  
24 structure.



1  
2 33. The sensor as in Claim 32, wherein said first material  
3 comprises a first face centered cubic material and said second  
4 material comprises a second face centered cubic material.

5  
6 34. The sensor as in Claim 33, wherein said absolute value is  
7 less than approximately 0.12 eV.

8  
9 35. The sensor as in Claim 33, wherein said second material is  
10 selected from the group comprising Cu, Ag, Al, Au, Ir, Pt, Pd,  
11 Rh, and binary, ternary and higher order alloys of said elements.

12  
13 36. The sensor as in Claim 33, wherein said second material is  
14 selected from the group comprising  $\text{Ag}_3\text{Pt}$ ,  $\text{AgPt}_3$ ,  $\text{Cu}_3\text{Pt}$ ,  $\text{CuPt}$ ,  
15  $\text{CuPt}_3$ ,  $\text{Cu}_3\text{Pt}_5$ ,  $\text{Cu}_3\text{Au}$ ,  $\text{Cu}_3\text{Pd}$ ,  $\text{CuPd}$ ,  $\text{CrIr}_3$ ,  $\text{Cr}_2\text{Pt}$  and mixtures of  
16 said materials.

17  
18 37. The sensor as in Claim 33, wherein said first material is  
19 selected from the group comprising 80Ni:20Fe,  $\text{Ni}_3\text{Fe}$ ,  $\text{Ni}_3\text{Mn}$ ,  $\text{Fe}_4\text{Mn}$ ,  
20  $\text{FePd}$ ,  $\text{Fe}_{1-y}\text{Au}_y$ , where y is an atomic fraction with a value  
21 between 0.30 and 0.70,  $\text{Co}_{1-z}\text{Au}_z$ , where z is an atomic fraction  
22 with a value between 0.10 and 0.50, 90Co:10Fe,  $\text{Fe}_{0.485}\text{Ni}_{0.418}$   
23  $\text{Mn}_{0.097}$ ,  $(48\text{Co}:29\text{Ni}:23\text{Fe})_{(1-y)}\text{Pd}_y$ ,  $(26\text{Co}:44\text{Ni}:30\text{Fe})_{(1-y)}\text{Pd}_y$ , where y is

1 an atomic fraction of Pd with a value between 0.12 to 0.30,  
2 33.6Co:20.3Ni:16.1Fe:30Pd, and 18.2Co:30.8Ni:21Fe:30Pd.

3

4 38. The sensor as in Claim 32, wherein said first material  
5 comprises a first body centered cubic material and said second  
6 material comprises a second body centered cubic material.

7

38

8 39. The sensor as in Claim 36, wherein said absolute value is  
9 less than approximately 0.07 eV.

10

11 40. The sensor as in Claim 38, wherein said second material is  
12 selected from a group consisting of Cr, W, V, Nb, Mo, Ta and  
13 binary ternary and higher order alloys of said elements.

14  
15 41. The sensor as in Claim 38, wherein said first material is  
16 selected from the group comprising  $Fe_{1-u}Cr_u$ , where u is the  
17 atomic fraction with a value between 0.40 and 0.70,  $Fe_{1-w}V_w$ ,  
18 where w is the atomic fraction with a value between 0.25 and  
19 0.35, ternary alloys of Fe, Cr and V, and  $Fe_3Al$ .

20

21 42. The sensor as in Claim 27, wherein said first  
22 electronegativity corresponds to a first work function;  
23 wherein said second electronegativity corresponds to a second  
24 work function; and

1 wherein said at least first and second work functions are  
2 matched for optimizing the interfacial properties of the data  
3 storage device.

4  
5 43. The sensor as in Claim 27, wherein said first and second  
6 electronegativities are defined according to the following  
7 equations, respectively:

8 
$$\chi \text{ (FM)} = 0.44 \phi \text{ (FM)} - 0.15, \text{ and}$$

9 
$$\chi \text{ (spacer)} = 0.44 \phi \text{ (spacer)} - 0.15,$$

10 where  $\chi \text{ (FM)}$  and  $\chi \text{ (spacer)}$  are said first and second  
11 electronegativities, respectively, and  $\phi \text{ (FM)}$  and  $\phi \text{ (spacer)}$  are  
12 the work functions of said ferromagnetic layer, and said  
13 electrically conductive spacer, respectively.

14  
15 44. The sensor as in Claim 43, wherein said second material  
16 comprises a conductive alloy having an electronegativity  $\chi_A$  and  
17 formed of a plurality of elements 1 through i;

18 wherein said elements have electronegativities  $\chi_1$  through  $\chi_i$ ,  
19 and atomic fractions  $f_1$  through  $f_i$ , respectively; and

20 wherein said  $\chi_A$  is defined by the following equation:

21 
$$\chi_A = \chi_1 f_1 + \chi_2 f_2 \dots \chi_i f_i$$
  
22

1 45. The sensor as in Claim 43, wherein said first material  
2 comprises ferromagnetic alloy having an electronegativity  $\chi_B$  and  
3 formed of a plurality of elements 1 through j;

4 wherein said elements have electronegativities  $\chi_1$  through  $\chi_j$ ,  
5 and atomic fractions  $f_1$  and  $f_j$ , respectively; and

6 wherein said  $\chi_B$  is defined by the following equation:

7 
$$\chi_B = \chi_1 f_1 + \chi_2 f_2 \dots \chi_j f_j$$

8

9 46. The sensor as in Claim 27, wherein said first material  
10 comprises a material having a bulk resistivity of less than  
11 approximately 100  $\mu\Omega$ -cm.

12  
13 47. The sensor as in Claim <sup>38</sup>~~46~~, wherein said third material  
14 comprises a material having a bulk resistivity of less than  
15 approximately 100  $\mu\Omega$ -cm.

16  
17 48. The sensor as in Claim <sup>30</sup>~~27~~, wherein said second material  
18 comprises a material having a bulk resistivity of less than  
19 approximately 30  $\mu\Omega$ -cm.

20  
21 49. ~~The~~ The sensor as in Claim 27, wherein said first material is a  
22 first Heusler alloy.

1  
2 50. The sensor as in Claim 49, wherein said first Heusler alloy  
3 has a composition of  $M_1MnM_2$ , where  $M_1$  is an element selected from  
4 the group consisting of Al, Ga, Ge, As, In, Si, Sn and Bi, and  $M_2$   
5 is an element selected from the group consisting of Co, Ni, Cu,  
6 Ir, Pd, Pt and Au.

7  
8 51. The sensor as in Claim 50, wherein said second material  
9 comprises a second Heusler alloy that is nonferromagnetic and  
10 wherein  $M_2$  is an element selected from the group consisting of  
11 Pt, Au, Pd and Ir, said second Heusler alloy having a bulk  
12 resistivity of less than approximately  $30 \mu\Omega\text{-cm}$ .

13  
14 52. The sensor as in Claim 27, wherein said second material  
15 comprises a material from the group consisting of Cu,  $Cu_{1-x}Au_x$ ,  
16 where  $x$  is an atomic fraction between .05 and .15,  $Al_2Au$ ,  $PtAl_2$   
17 and  $Ag_{1-y}Au_y$ , where  $y$  is an atomic fraction less than .25.

18  
19 53. A method of optimizing the interfacial properties of a  
20 magnetoresistive sensor comprising the steps of:  
21 selecting a substrate having a predetermined crystallographic  
22 orientation;

1 selecting ferromagnetic layers, each having a crystallographic  
2 orientation similar to said substrate crystallographic structure  
3 and having a first electronegativity; and

4 selecting at least one electrically conductive spacer having a  
5 crystallographic orientation similar to said ferromagnetic  
6 crystallographic structure and having a second electronegativity;

7 wherein an absolute value of a difference between said first  
8 and second electronegativities is minimized.

9  
10 54. The method as in Claim 53, wherein, each of said selecting  
11 steps includes selecting a single crystal material for said  
12 substrate, said ferromagnetic layers and said electrically  
13 conductive spacer.

14  
15 55. The method as in Claim 53, wherein said step of selecting  
16 said substrate includes selecting a substrate material with a  
17 face centered cubic structure;

18 wherein said step of selecting said ferromagnetic layers  
19 includes selecting a ferromagnetic layer material with a face  
20 centered cubic structure; and

21 wherein said step of selecting said conductive spacer includes  
22 selecting a spacer material with a face centered cubic structure.

56. The method as in Claim 55, wherein said absolute value is less than approximately 0.14 eV.

57. The method as in Claim 53, wherein said step of selecting said substrate includes selecting a substrate material with a body centered cubic structure;

wherein said step of selecting said ferromagnetic layers includes selecting a ferromagnetic layer material with a body centered cubic structure; and

wherein said step of selecting said conductive spacer includes selecting a spacer material with a body centered cubic structure.

58. A method of optimizing the interfacial properties of a magnetoresistive sensor comprising the steps of:

selecting a substrate having a random crystallographic orientation;

selecting ferromagnetic layers, each having a random crystallographic orientation and having a first electronegativity; and

selecting an electrically conductive spacer having a random crystallographic orientation and having a second electronegativity;

1 wherein said selecting steps provide for minimizing an  
2 absolute value of a difference between said first  
3 electronegativity and said second electronegativity.  
4

5 59. The method as in Claim 58, wherein said step of selecting  
6 said substrate includes selecting a substrate material with a  
7 face centered cubic structure;

8 wherein said step of selecting said ferromagnetic layers  
9 includes selecting a ferromagnetic layer material with a face  
10 centered cubic structure; and

11 wherein said step of selecting said conductive spacer includes  
12 selecting a spacer material with a face centered cubic structure.  
13

14 60. The method as in Claim 59, wherein said absolute value is  
15 less than approximately 0.12 eV.  
16

17 61. The method as in Claim 59, wherein said step of selecting  
18 said substrate includes selecting a substrate material with a  
19 body centered cubic structure;

20 wherein said step of selecting said ferromagnetic layers  
21 includes selecting a ferromagnetic layer material with a body  
22 centered cubic structure; and

23 wherein said step of selecting said conductive spacer includes  
24 selecting a spacer material with a body centered cubic structure.



1  
2 62. The method as in Claim 61, wherein said absolute value is  
3 less than approximately 0.07 eV.  
4

5 63. A method of optimizing the interfacial properties of a  
6 magnetoresistive sensor comprising the steps of:

7 selecting a substrate having a predetermined crystallographic  
8 orientation;

9 selecting ferromagnetic layers, each having a crystallographic  
10 orientation substantially similar to said substrate  
11 crystallographic orientation and having a first work function;  
12 and

13 selecting at least one electrically conductive spacer having a  
14 crystallographic orientation similar to said substrate  
15 crystallographic orientation and having a second work function;

16 wherein said selecting steps include the step of substantially  
17 minimizing a difference between said first and second work  
18 functions.  
19

20 64. A method of optimizing the interfacial properties of a  
21 magnetoresistive sensor comprising the steps of:

22 selecting a substrate having a random crystallographic  
23 orientation;

1 selecting ferromagnetic layers, each having a random  
2 crystallographic orientation and having a first work function;  
3 and

4 selecting an electrically conductive spacer having a random  
5 crystallographic orientation and having a second work function;

6 wherein said selecting steps include minimizing a difference  
7 between said first and second work functions.

8  
9 65. A magnetoresistive sensor comprising:

10 a substrate having a predetermined crystallographic  
11 orientation;

12 ferromagnetic layers, each having a crystallographic  
13 orientation similar to said substrate crystallographic  
14 orientation and having a first electronegativity; and

15 at least one electrically conductive spacer interposed between  
16 said ferromagnetic layers and having a crystallographic  
17 orientation similar to said substrate crystallographic  
18 orientation and having a second electronegativity;

19 wherein an absolute difference between said first and second  
20 electronegativities is minimized for optimizing the interfacial  
21 properties of the sensor.

66. The sensor as in Claim 65, wherein said ferromagnetic layers ~~comprise~~ single crystal structures and said electrically conductive spacer comprises a single crystal.

67. The sensor as in Claim 65, wherein said substrate comprises a material having a face centered cubic structure;

wherein said ferromagnetic layers comprise materials having face centered cubic structures; and

wherein said conductive spacer comprises a material having a face centered cubic structure.

68. The sensor as in Claim 67, wherein said absolute value is less than approximately 0.14 eV.

69. The sensor as in Claim 65, wherein said substrate comprises a material having a body centered cubic structure;

wherein said ferromagnetic layers comprise materials having a body centered cubic structure; and

wherein said conductive spacer comprises material having a body centered cubic structure.

70. A magnetoresistive sensor comprising:

a substrate having a random crystallographic orientation;

1 ferromagnetic layers, each having a random crystallographic  
2 orientation and having a first electronegativity; and

3 an electrically conductive spacer interposed between said  
4 ferromagnetic layers and having a random crystallographic  
5 orientation and having a second electronegativity;

6 wherein an absolute difference between said first and second  
7 electronegativities is minimized for optimizing the interfacial  
8 properties of the sensor.

9  
10 71. The sensor as in Claim 70, wherein said substrate comprises  
11 a material having a face centered cubic structure;

12 wherein said ferromagnetic layers comprise materials having  
13 face centered cubic structures; and

14 wherein said conductive spacer comprises a material having a  
15 face centered cubic structure.

16  
17 72. The sensor as in Claim 71, wherein said absolute value is  
18 less than approximately 0.12 eV.

19  
20 73. The sensor as in Claim 70, wherein said substrate comprises  
21 a material having a body centered cubic structure;

22 wherein said ferromagnetic layers comprise materials having a  
23 body centered cubic structure; and

1 wherein said conductive spacer comprises material having a  
2 body centered cubic structure.

3  
4 74. The sensor as in Claim 73, wherein said absolute value is  
5 less than approximately 0.07 eV.

6  
7 75. The magnetoresistive sensor as in Claim 70, wherein said  
8 ferromagnetic layers each comprise crystals having three faces:  
9 111, 110 and 100, having individual electronegativities  $\chi_{111}$ ,  $\chi_{100}$ ,  
10 and  $\chi_{110}$ , respectively; and

11 wherein said first electronegativity is defined by the  
12 following equation:

13 
$$\chi(\text{average}) = 1/3 (\chi_{111} + \chi_{100} + \chi_{110}).$$

14  
15 76. The sensor as in Claim 70, wherein said electrically  
16 conductive ~~spacer~~ comprises crystals having three faces: 111, 110  
17 and 100, having individual electronegativities  $\chi_{111}$ ,  $\chi_{100}$ , and  $\chi_{110}$ ,  
18 respectively; and

19 wherein said second electronegativity is defined by the  
20 following equation:

21 
$$\chi(\text{average}) = 1/3 (\chi_{111} + \chi_{100} + \chi_{110}).$$

22  
23 77. The sensor as in Claim 27, further comprising:

1 a substrate in atomic contact with a side of one of said  
2 ferromagnetic layers opposite said spacer; and  
3 an antiferromagnetic layer in atomic contact with a side of  
4 another one of said ferromagnetic layers opposite said spacer;  
5 wherein the sensor is a spin valve sensor.

6  
7 78. The sensor as in Claim 77 further comprising a buffer layer  
8 interposed between one of said ferromagnetic layers and said  
9 substrate.

10  
11 79. The sensor in Claim 78, wherein said buffer layer is an  
12 element selected from a group consisting of Ta, Cr, Fe, Pt, Pd,  
13 Ir and Au.

14  
15 80. The sensor as in Claim 27, further comprising:  
16 a substrate in atomic contact with a side of one of said  
17 ferromagnetic layers opposite said spacer;  
18 wherein the sensor is a giant magnetoresistive sensor, and  
19 said first and second ferromagnetic layers comprise a plurality  
20 of said first and second ferromagnetic layers and said  
21 electrically conductive spacer comprises a plurality of said  
22 spacers.

81. The sensor as in Claim 80 further comprising a buffer layer interposed between one of said ferromagnetic layers and said substrate.

82. The sensor as in Claim 81, wherein said buffer layer is an element selected from a group consisting of Ta, Cr, Fe, Pt, Pd, Ir and Au.

83. A magnetoresistive sensor comprising in combination:  
a substrate;

ferromagnetic layer means formed over said substrate and having a first electronegativity; and

electrically conductive spacer means formed on said ferromagnetic layer and having a second electronegativity;

wherein a magnetoresistive response characteristic ( $\Delta R/R$ ) of the sensor is optimized by correlating said first and second electronegativities to  $\Delta R/R$  by the following equation:

$$\Delta R/R \cong A - B |\Delta\chi|^n,$$

where A and B are constant values and  $|\Delta\chi|$  is an absolute value of the difference between said first and second electronegativities.

1 84. The sensor as in Claim 83, wherein said ferromagnetic layer  
2 means constitutes a plurality of ferromagnetic layers; and said  
3 conductive spacer means comprises a number of spacer layers  
4 interposed between said ferromagnetic layers; and  
5 wherein said absolute value is minimized.

6  
7 85. The sensor as in Claim 84, wherein said substrate comprises  
8 a material having a face centered cubic structure;  
9 wherein said ferromagnetic layers comprise materials having  
10 face centered cubic structures; and  
11 wherein said conductive spacer comprises a material having a  
12 face centered cubic structure.

13  
14 86. The sensor as in Claim 85, wherein said absolute value is  
15 less than 0.12 eV.

16  
17 87. A method of optimizing the magnetoresistive response  
18 ( $\Delta R/R$ ) of a magnetoresistive sensor, comprising the steps of:  
19 selecting ferromagnetic layers having at least a first  
20 electronegativity;  
21 selecting at least one electrically conductive spacer having  
22 at least a second electronegativity; and



1 wherein said selecting steps include correlating said first  
2 and second electronegativities for optimizing  $\Delta R/R$  in accordance  
3 with the following equation:

$$\Delta R/R \cong A - B |\Delta\chi|^2,$$

4  
5 where A and B are constant values and  $|\Delta\chi|$  is an absolute value  
6 of the difference between said first and second  
7 electronegativities.

8  
9 88. The method according to Claim 87, wherein said step of  
10 correlating includes the step of optimizing  $\Delta R/R$  in view of the  
11 following relationship:

$$\Delta R/R \cong A - 2A |\Delta\chi|^2.$$

12  
13  
14 89. The method according to Claim 88, wherein the sensor  
15 includes a spin valve sensor, including the step of setting the  
16 constant value A equal to approximately 32.30.

17  
18 90. The method according to Claim 88, wherein the sensor  
19 includes a giant magnetoresistive sensor having a first peak,  
20 including the step of setting the constant value A equal to  
21 approximately 245 for said first peak.

1 91. The method according to Claim 88, wherein the sensor  
2 includes a giant magnetoresistive sensor having first and second  
3 peaks, including the step of setting the constant value A equal  
4 to approximately 110 for said second peak.

5  
6 92. The method according to Claim 88, wherein the sensor  
7 includes a giant magnetoresistive sensor having first, second and  
8 third peaks, including the step of setting the constant value A  
9 equal to approximately 45 for said third peak.

10  
11 93. A magnetoresistive sensor comprising:  
12 first and second ferromagnetic layers, wherein at least one of  
13 said layers comprise a superlattice material; and  
14 an electrically conductive spacer interposed between said  
15 ferromagnetic layers.

16  
17 ~~94. The sensor of Claim 93, wherein said electrically~~  
18 ~~conductive spacer comprises a superlattice material.~~

19  
20 95. The sensor of Claim 93, wherein said first ferromagnetic  
21 layer has a first electronegativity, said electrically conductive  
22 spacer has a second electronegativity and an absolute value of a  
23 difference between said first and second electronegativities is  
24 minimized.

1  
2 96. A magnetoresistive sensor comprising:

3 first and second ferromagnetic layers; and  
4 an electrically conductive spacer interposed between said  
5 ferromagnetic layers, wherein said spacer comprises a  
6 superlattice material.

7  
8 97. The sensor of Claim 96, wherein at least one of said  
9 ferromagnetic layers comprises a superlattice material.

10  
11 98. The sensor of Claim 96, wherein said first ferromagnetic  
12 layer has a first electronegativity, said electrically conductive  
13 spacer has a second electronegativity and an absolute value of a  
14 difference between said first and second electronegativities is  
15 minimized.

16  
17 99. A magnetoresistive sensor comprising:

18 a first and second ferromagnetic layer; and  
19 an electrically conductive spacer interposed between said  
20 ferromagnetic layers;

21 wherein said first ferromagnetic layer comprises a first  
22 compound ferromagnetic layer having a first material with a first  
23 magnetostriction and a first thickness and a second ferromagnetic

1 material with a second magnetostriction and a second thickness;  
2 and

3 wherein a difference between a first product of said first  
4 thickness and said first magnetostriction and a second product of  
5 said second thickness and said second magnetostriction is  
6 minimized.

7  
8 100. The sensor as in Claim 99, wherein a ratio between said  
9 first and second products is in a range of approximately .3 to  
10 approximately 3.

11  
12 101. The sensor as in Claim 99, wherein said first and second  
13 materials have a first and second coercivity, respectfully, and  
14 an average of said first and second coercivities is minimized.

15  
16 102. The sensor as in Claim 101, wherein said average is less  
17 than approximately ten oersteds.

18  
19 103. The sensor as in Claim 99, wherein said first ferromagnetic  
20 material has a first electronegativity and is in atomic contact  
21 with said electrically conductive spacer, wherein said spacer has  
22 a second electronegativity and wherein an absolute value of a  
23 difference between said first and second electronegativities is  
24 minimized.

1  
2 104. The sensor as in Claim 99, wherein said second  
3 ferromagnetic layer comprises a second compound ferromagnetic  
4 layer having a third ferromagnetic material and a fourth  
5 ferromagnetic material in atomic contact with said electrically  
6 conductive spacer, and wherein said first and fourth  
7 ferromagnetic materials comprise substantially the same  
8 composition and said second and third ferromagnetic materials  
9 comprise substantially the same composition.